

AD904920

SWERR-TR-72-65

AD

**LIQUID POLYMERS AS COATINGS FOR
IMPROVED COATED FABRICS**

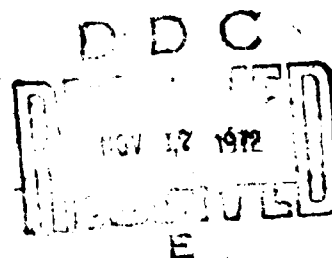
(Supplement to RE-TR-71-51)



TECHNICAL REPORT

William F. Garland

September 1972



**RESEARCH DIRECTORATE
WEAPONS LABORATORY, WECOM
RESEARCH, DEVELOPMENT AND ENGINEERING DIRECTORATE
U. S. ARMY WEAPONS COMMAND**

Distribution limited to U. S. Government agencies only; (Test and Evaluation); September 1972. Other requests for this document must be referred to U. S. Army Weapons Command, SWERR-R.

DISPOSITION INSTRUCTIONS: .

Destroy this report when it is no longer needed. Do not return it to the originator.

DISCLAIMER:

The findings of this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The citation of commercial products in this report does not constitute an official indorsement or approval of such products.

NTIS DISCLAIMER

- ❖ This document has been reproduced from the very best copy that was furnished by the Source Agency. Although NTIS realizes that parts of this document may be illegible, it is being released in order to make available as much information as possible.

AD

RESEARCH DIRECTORATE
WEAPONS LABORATORY, WECOM
RESEARCH, DEVELOPMENT AND ENGINEERING DIRECTORATE
U. S. ARMY WEAPONS COMMAND
TECHNICAL REPORT
SWERR-TR-72-65

LIQUID POLYMERS AS COATINGS FOR
IMPROVED COATED FABRICS
(Supplement to RE-TR-71-51)

William F. Garland

September 1972

DA 1T062105A329

AMS Code 502E.11.295

Distribution limited to U. S. Government agencies only; (Test and Evaluation); September 1972. Other requests for this document must be referred to U. S. Army Weapons Command, SWERR-R.

Rock Island, Ill. 161201

ABSTRACT

Results are presented for the second years' effort of a two-year program initiated by personnel of the Research Directorate, Weapons Laboratory, WECOM concerning the use of liquid polymers as coatings for fibrous and nonfibrous substrates to provide improved weapon accessories such as gun covers and cleaning kit packets. Both pigmented and nonpigmented coatings were investigated.

Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength.

Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates.

Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent.

Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics.

The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

CONTENTS

	<u>Page</u>
TITLE PAGE	i
ABSTRACT	ii
TABLE OF CONTENTS	iii
OBJECTIVE	1
BACKGROUND	1
APPROACH	2
RESULTS AND DISCUSSION	7
CONCLUSIONS	15
RECOMMENDATIONS	16
LITERATURE CITED	17
DISTRIBUTION	18
DD FORM 1473 (Document Control Data - R&D)	24

This page intentionally left blank.

OBJECTIVE

The objective of the program was to investigate the use of liquid polymers as coatings for fabrics to meet specific Army weapon system needs, including flexibility at low temperatures, resistance to abrasion and, good environmental stability.

BACKGROUND

Coated fabrics are used in a wide variety of Army applications such as tarpaulins, gun covers, helicopter covers, pneumatic floating equipment, aircraft protectors, air supported shelters, gun shield mantle covers and fuel storage containers.

The bulk of these coated fabrics is prepared by application of solid rubber or rubberlike coatings to various substrate fabrics. The largest volume of commercial coated fabrics is in the area of coated polyvinyl chloride materials.^{1,2} Industry primarily supplies neoprene and vinyl coated fabrics to the Army.

Although satisfactory for most civilian needs, current industrial coated fabrics do not meet these specialized requirements of the military for flexibility at low temperature, abrasion resistance, and fungus resistance.

Liquid polymers (polymeric materials fluid at room temperature or readily liquified by the process of heating without causing degradation) with many of these specialized properties are currently available. Liquid polymers are also reportedly superior to the solid materials (i.e., neoprene and vinyl) in several ways. They are normally ready to use as received and need no laborious production workup, little or no solvents are required and, as a result, these liquid polymers exhibit little shrinkage. Despite their many good features, very little effort has been expended by industry, in the use of liquid polymers as fabric coatings.

Previous work in this area³ indicated that laboratory prepared coated fabrics made with liquid polyurethanes had good abrasion, ozone, and low-temperature resistance.

The work reported here was initiated by personnel of the Research Directorate, Weapons Laboratory, WECOM, and is a continuing investigation of the feasibility of the

use of "liquid" polymers as coatings for fibrous substrates to obtain improved coated-fabrics.

APPROACH

As previously reported,³ the liquid polyurethane materials were the best of the liquid polymers tested. For this reason, only polyurethanes were investigated during this second year's activity.

The liquid polymers and fibrous substrates obtained for laboratory fabrication of coated fabrics are shown in Table I. Two commercial coated-fabrics, i.e., Type II, Class 2 (vinyl) and Type III, Class B (neoprene), meeting the requirements of Specification MIL-C-20696⁴ were used as controls.

A solid (resinous) polyurethane (Estane 5714 F-1) was included in the test program for comparison purposes. Two of the liquid polymers were semisolid at room temperature.

From 15 to 20 techniques are used to coat various textile materials, the two most often used are the knife and the roller coating techniques. The only laboratory bench coater (of the reverse roll type) available at this Directorate was not adaptable for use with the various viscosities of coating materials utilized, i.e., the very thin, watery Chemglaze material did not adhere to the rolls and the viscous Adiprene material was too tacky. In light of the above, dip coating was used since it was adaptable in all cases.

The following procedures were used to dip coat the polymers investigated:

Vibrathane B-602 and B-605. These polyether urethanes are solid in the as-received state. Used in the molten condition, they yielded extremely thick coatings. When diluted to 50 per cent solids with toluene, the polymer solution could be used at room temperature. Since most urethanes can be partially cured by reaction with moisture, pieces of the substrate materials (15 by 30 inches) were dip-coated in the polymer solution, by the method indicated in the figure, drained and hung in a controlled atmosphere (75°F, 50 per cent R.H.) for three days. The resultant coatings were tough, smooth, and relatively bubble-free.

TABLE I

IDENTIFICATION OF SUBSTRATES AND LIQUID POLYMER COATINGS

<u>Substrate</u>	<u>Trade Name</u>	<u>Manufacturer</u>
Nylon (open mesh)	A-2951/6	Stern and Stern Textiles, Inc.
Betaglass/Dynel	GV-4030-01	West Point Pepperell
Spunbonded Nylon	Cerex 5915	Monsanto Co.
Spunbonded Polyester	Reemay 2011	E.I. Dupont

<u>Liquid Polymer Coating</u>	<u>Trade Name</u>	<u>Manufacturer</u>
Polyurethane (polyether)	Adiprene L-100	E.I. Dupont
Polyurethane (polyester)	Chemglaze 2004	Hughson Chemical Co.
Polyurethane (polyether)	Vibrathane B-602	Uniroyal
Polyurethane (polyether)	Vibrathane B-605	Uniroyal
Polyurethane (polyether)	Estane 5714 F-1	B. F. Goodrich Chemical Co.

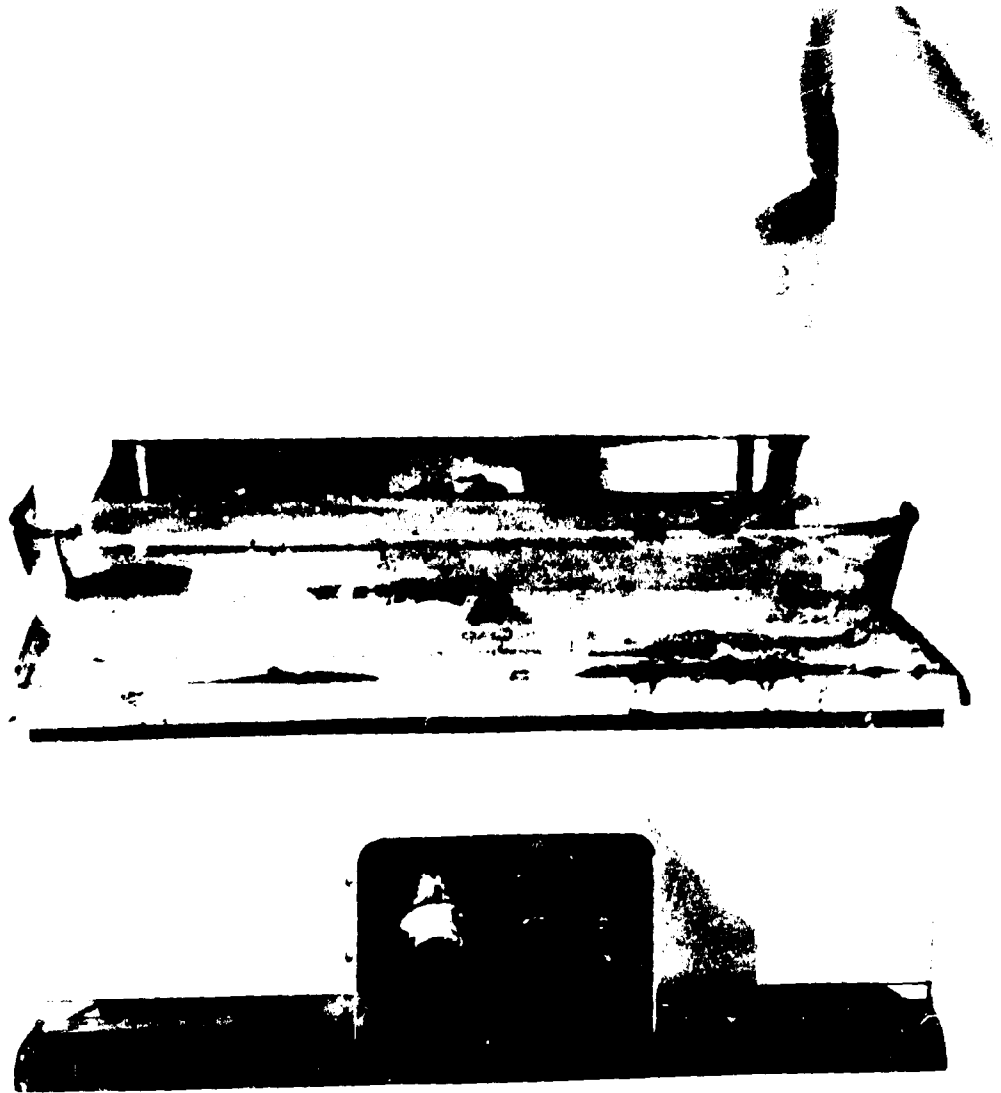


FIGURE Dip Coating of Fabrics

semiglaze 2004. This is a 35 per cent solids polyurethane coating. Dip coating was the same as that of the B-602 material except that no dilution was necessary and the substrates normally required two coats.

Adiprene L-100 This extremely thick molasses-like polyether liquid polymer is normally cured with a diamine. First attempts at coating with this polymer indicated that its short potlife (3-10 minutes), when the recommended diamine curative was used, would not permit the fabrication of the quantity of coated fabric material required for testing purposes. Also, the coatings were frequently lumpy. The Adiprene L-100 was dip coated in the same manner as the B-602 material and with the same solvent.

An attempt was made to hasten the "moisture" cure-time of the Adiprene and Vibrathane materials with the addition of 0.05 to 0.1 parts of adipic acid. The addition of the adipic acid appeared to decrease the cure time, but the coatings formed contained an excessive amount of bubbles.

Estane 5714 F-1 This is a solution grade polyether urethane resin soluble in a variety of solvents including ketones, toluene, tetrahydrofuran (THF), dimethylformamide (DMF), and dimethylsulfoxide (DMSO). The drying rates of the 5714 F-1 resin solutions are dependent upon the solvent used. An approximately 10 per cent solids solution of 5714 F-1 in 70/30 acetone/THF gave the best solution viscosity for dip coating. All substrates received three coats applied in the same manner used with B-602 material except that only one hour of drying time was required between coats.

All resinous coatings were clear and semiglossy. In an effort to obtain ultraviolet light-resistant materials, black pigmented coatings were prepared by addition of five to ten parts per hundred of a 1:1 combination of a fine thermal (FT) carbon black/trioctylphosphate to the various urethane solutions.

Results of the evaluation of coated fabrics described in the previous year's work and aged for six months outdoors in Panama are also included in this investigation.

The test methods used to evaluate the experimental and control coated fabrics are shown in Table II.

TABLE II

PROPERTIES DETERMINED AND TEST METHODS USED¹.

<u>Property</u>	<u>Method</u>
Weight, oz./sq.yd.	F.T.M.S.* 191, Method 5041
Thickness, Inch	F.T.M.S. 191, Method 5030
Breaking Strength, lb.	F.T.M.S. 191, Method 5102 ₂
Abrasion-Resistance	F.T.M.S. 191, Method 5304 ₂
Low Temperature Flexibility	3.
Heat Stability	4.
Fungus Resistance	191, Method 5760
Ozone Resistance	5.
Chemical Resistance	6.
Weathering Resistance	F.T.M.S. 191, Method 5804
Tear Resistance	ASTM Method D1004
Hydrolytic Stability	7.

*Federal Test Method Standard 91

1. All testing was performed at 73°F and 50% R.H. (Federal Test Method Standard 406, Section 4) unless otherwise indicated in the applicable test method.
2. Modified as follows: 240-grit paper, 6-pound load, 3.5 pound tension, 1000 cycles.
3. Specimens (1 inch by 6 inches) were conditioned for four hours at -67°F and then flexed over a 1/4-inch mandrel.
4. Temperature, pressure, and dwell time were varied on the impulse and thermal heat sealers as required to obtain proper heat seal.
5. Specimens (1 inch by 3 inches) were bent and wrapped around 1/16, 1/8, and 1/4 inch rods and exposed in an ozone chamber maintained at 100°F \pm 2°F and 50 \pm 5 ppm ozone for seven days. Time to first crack was observed under 7-power magnification.
6. Specimens were 2 inches by 4 inches. Test fluids were MIL-L-46000, Lubricating Oil; IT-S-735, Type II Fuel (60/5/20/15 Iso-Octane/Benzene/Toluene/Xylene); and O-I-503, Type I Insect Repellent. The chemical resistance of the coated fabrics was evaluated as follows: one-half of a specimen was covered with a test fluid and the results were observed after 7 days at 73°F and 50 per cent R.H.
7. Specimens 1 inch by 4 inches were suspended over 200 milliliters of distilled water in a tightly sealed one-quart jar. The assembly was placed in an oven maintained at 158°F for 30 days.

RESULTS AND DISCUSSION

Substrates

The properties of two woven and two nonwoven fabrics, as received from industry, are listed in Table III. The woven nylon material is similar to the base fabric used in MIL-C-20696. This weight of fabric is strong, relatively easy to coat, and has a good hand (drape-flexibility). Although the woven Betaglass fabric is somewhat less flexible and weaker than the nylon material, it is more resistant to the effects of ultraviolet light than nylon (most noticeable in the cross direction, Table III). The nonwoven materials were selected for investigation because of three important characteristics; they are lightweight, flexible, and inexpensive. The price range of nonwovens is from 20 to 85 cents per square yard for a 5-ounce standard-weave nylon fabric. The overall properties of the spunbonded Cerex nylon were superior to those of the spunbonded Reemay polyester. However, the resistance to deterioration by ultraviolet light was relatively the same for both fabrics.

Liquid Polymers

The properties of the liquid polymers used to coat the substrates, shown in Table III, are presented in Table IV (unpigmented materials) and Table V (black pigmented materials). The chemical resistance of the coated fabrics is given in Table VI.

The four "liquid" urethane polymers varied widely in viscosity, i.e., from the water-thin Chemglaze to the very thick Adiprene (approximately 30 to 20,000 CPS, respectively, at 77°F) and the extremely thick (semisolid) Vibrathanes. The 10 per cent solids solution of the Estane resin in Acetone/THF was approximately the same viscosity as the Chemglaze coating material.

The resin pickup was greatest for the closely woven Betaglass fabric. This high resin pickup caused the coated Betaglass fabrics to be the stiffest of the materials tested. The thinner, lighter weight Chemglaze coatings ranked next in stiffness. Strike through or penetration of the coating into the fibers was also a contributing factor in the stiffening of Betaglass coated fabrics. However, while all Betaglass coated-fabrics were stiff at room temperature, the coatings could be bent sharply, or folded, at -67°F without cracking. The resin pickup on the remaining three substrates varied dependent upon the liquid

TABLE III
PROPERTIES OF FIBROUS SUBSTRATES

	Nylon A-2951/6	Betaglass GV-4030-01	Cerex 5915	Reemay 2011
Weight, oz./sq.yd.	4.5	6.4	1.6	1.2
Thickness, in.	.014	.014	.006	.009
Machine direction	240	197	22	14
Cross direction	203	201	10	8
Fungus Resistance	← NO GROWTH →			
Low Temperature Flexibility	← NO CRACKING →			
Tear Resistance	NO TEST*	2.0	5.9	1.8
Tests after 150 hours accelerated aging				
Breaking Strength, lb:				
Machine direction	195	175	12	8
Cross direction	105	165	10	4
Visual Examination	NO VISIBLE EFFECT	SLIGHT DARKENING	NO VISIBLE ← EFFECT	→

*Individual threads pulled out

TABLE IV
PROPERTIES OF UNPIGMENTED COATED-FABRICS

As	B602					B605					Nyl
	Cerex	Reemay	Nylon	Beta-glass	Cerex	Reemay	Nylon	Beta-glass	Cerex	Reemay	
7	.010	.009	.019	.041	.012	.016	.023	.043	.021	.017	.01
4	7.7	6.6	12.8	25.7	7.7	15.3	18.8	24.1	17.4	11.9	10
	46	18	266	190	28	14	266	204	37	30	286
	28	16	105	159	22	14	128	174	32	27	161
	4.7	2.8	28	23	6.3	3.5	26	24	10.4	7.6	26
	NO FUNGAL GROWTH AFTER 28 DAYS										
	NO CRACKING AT -67°F										
	NOT HEAT SEALABLE										
	DISCOLORATION	NO CRACKING NOT TACKY									
	ING AFTER 7 DAYS										
	SEE TABLE VI										
	0.56	-	0.30	-	0.15	-	0.11	-	0.04	-	0.4
	34	17	181	171	28	9	170	179	27	12	143
	5.7	2.7	11.2	28	5.6	2.0	12	20	6.2	1.5	19
es	color	color	color	surface	color	color	color	surface	color	color	color
ss	darkened	darkened	darkened	bubbles	darkened	darkened	darkened	bubbles	darkened	darkened	darkened

(COLUMNAR)

(TO BE USED ONLY AS A WORKSHEET . . . NOT TO BE OVERPRINTED)

DRM

B605				5714F1				CONTROL MATERIALS		
Nylon	Beta-glass	Cerex	Reemay	Nylon	Beta-glass	Cerex	Reemay	Vinyl	Necprene	
.023	.043	.021	.017	.021	.021	.008	.007	.024	.020	
18.5	24.1	17.4	11.9	10.3	11.1	4.9	4.4	23	18	
266	304	37	30	286	230	35	16	360	315	
128	174	32	27	161	147	20	12	215	285	
26	24	10.4	7.6	26	20	5.5	3.8	29	30	
								light growth	no growth	
								cracks	no cracks	
								heat sealable	not heat sealable	
								sl. tacky	not tacky	
								no cracking	no cracking	
								pass	fail	
0.11	-	0.04	-	0.47	-	0.24	-	0.67	2.9	
70	179	27	12	143	207	25	9	325	295	
2	20	6.2	1.5	19	16	4.7	2	26	24	
color darkened	surface bubbles	color darkened	color darkened	color darkened	pinholes color darkened	color darkened	color darkened	color lightens	color lightens	

3RM (COLUMNAR)

(TO BE USED ONLY AS A WORKSHEET NOT TO BE OVERPRINTED)

PROPERTY OF

[illegible]

TABLE V
PROPERTIES OF PIGMENTED (BLACK) COATED FABRICS

B602		B605				B605				
Cerex	Reemay	Nylon	Beta-glass	Cerex	Reemay	Nylon	Beta-glass	Cerex	Reemay	Nyl
.009	.008	.021	.030	.011	.012	.018	.031	.012	.010	.02
8.8	6.6	15.9	27.4	14.7	12.3	15.0	22.4	10.7	10.3	9.1
35	22	232	197	33	15	249	223	38	21	248
25	14	127	121	22	12	112	167	26	20	99
4.4	2.6	19	19.5	6.3	3.4	21	23.5	9.8	5.2	25.
NO GROWTH AFTER 28 DAYS										
NO CRACKING AT -57°F										
NOT HEAT SEALABLE										
NO CRACKING - NOT TACKY										
NO CRACKING AFTER 7 DAYS										
SEE TABLE VI										
0.92	-	0.12	-	0.08	-	0.18	-	0.05	-	0.71
32	15	119	202	31	11	119	179	22	12	161
5.0	2.6	17.2	17.3	6.5	3.5	14.8	20.5	5.6	2.6	19.
slight pinholing	surface dulls	surface dulls, some pinholing	surface bubbles, pinholing	surface dulls	surface dulls	surface dulls	surface bubbles, some pinholing	surface dulls	surface dulls	surf dull some pinh

(COLUMNAR)

(TO BE USED ONLY AS A WORKSHEET - - - NOT TO BE OVERPRINTED)

B605				5714F1				Control Materials	
Nylon	Beta-glass	Cerex	Reemay	Nylon	Beta-glass	Cerex	Reemay	Vinyl	Neoprene
.018	.031	.012	.010	.020	.023	.008	.008	.024	.020
15.0	22.4	10.7	10.3	9.1	12.6	6.1	3.4	23	18
249	223	38	21	248	194	24	14	360	315
112	167	25	20	99	136	16	9	215	285
21	20.5	9.8	5.2	25.6	18.7	6.0	5.0	29	30
								Light growth	No growth
								Cracks	No cracks
								Heat sealable	Not heat sealable
								Sl. tacky	Not tacky
								No cracking	no cracking
								Pass	Fail
0.18	-	0.05	-	0.71	-	0.67	-	0.67	2.9
119	179	22	12	161	207	26	10	325	295
14.8	20.5	5.6	2.6	19.6	15.3	5.6	2.8	26	24
surface dulls	surface bubbles, some pinholing	surface dulls	surface dulls	surface dulls, some pinholing	surface pinholes	surface dulls	surface dulls	color lightens	color lightens

polymer used; however, the Estane coatings were generally heavier on the wovens and lighter on the nonwoven fabrics.

The substrate breaking strength was not always increased by application of liquid polymer coatings (Tables IV and V). Almost all of the coated fabrics made with woven substrates had significantly lower cross direction breaking strength. Some loss in strength may be due to variations in the coatings or cures, or due to deterioration by solvents used to dilute the polymers. However, the applied coating increased, significantly, the breaking strength of the coated fabrics made from the nonwoven substrates.

The tear strength of the laboratory-prepared, woven coated-fabrics was similar to that of the commercial controls made by spread or roller systems. Several attempts were made to decrease the penetration of the coating into the fabric and to increase the tearing strength. A base coat (tie-coat) of bis(aminomethyl)cyclohexane in methyl chloride was applied to fabric strips and, while the base coat was still slightly wet, a thin coating of liquid polymer was applied. The coating was dry in approximately one hour, but was very stiff and tear strength was not improved. In a second experiment, a thin coating of a liquid polymer was applied to fabric substrates that were then cured in an atmosphere of sym-dimethyl-ethylenediamine. With this treatment, the coatings were so rapidly cured that they became rough and lumpy. Again, tear strength was not improved. In general, the tear strength of the nonwovens was not significantly improved by application of polymer coatings.

All test materials were fungus- and ozone-resistant, and stiff at -67°F . The vinyl control supported light fungal growth and cracked badly when bent around a one-fourth-inch mandrel at -67°F . The neoprene control cracked badly after one day's exposure to ozone.

Only the coated fabrics made from the thermoplastic Estane material were heat sealable. Several attempts were made to coat the thermosetting materials with a thermoplastic resin to obtain heat-sealable materials. The thermoplastic overcoating was only a borderline success. While the coated fabric thus formed was heat sealable, the adhesion between the thermoset and thermoplastic layers was poor. As indicated in Tables IV and V, the vinyl control was heat sealable.

Since many coated-fabrics require extended use in an outdoor environment, hydrolytic stability is an important requirement. At this time, no standard procedure is available for testing coated fabrics for hydrolytic stability.⁵ The poor resistance to hydrolysis of polyester urethanes is well documented.^{6,7} However, none of the test coatings, including the polyester, became cracked or tacky at the end of the 30-day hydrolysis test (Tables IV and V). Current hydrolytic stability tests for solid rubbers that use a specified loss in stress-strain properties or cracking of stressed specimens as rejection criteria are not adaptable to coated fabrics since the high strength of the coated fabric substrate usually detracts from the value of such testing.

In general, the test coatings were superior in abrasion resistance to the vinyl and neoprene control materials. Both woven and nonwoven base materials were tested for abrasion resistance to determine if the flexibility and smoothness of the substrates would affect the abrasion resistance of the coatings. With the exception of the black pigmented Chemglaze coating, the nonwoven fabric-based coated fabrics had the greater abrasion resistance (Tables IV and V). The latter fabrics are also smoother and more flexible than the woven coated-fabrics.

The insect repellent had a severe effect on the Estane coated-fabrics and on the vinyl control (Table VI). Note that only 2 or 3 drops of the insect repellent were required to cover one-half of each test specimen. Neither the hydrocarbon fuel nor the lubricating oil had any serious effect on the various coated-fabrics.

The breaking-strength loss after accelerated aging was most severe on those coated fabrics containing a woven nylon substrate, i.e., bubbles or pockmarks were evident on some of the coating surfaces. This was true in both the nonpigmented and the pigmented materials. Betaglass based materials were the most resistant to the effects of accelerated aging. Tear strength after accelerated aging varied, possibly, because of further curing by the moisture sensitive materials.

The results obtained on materials aged for six months in Panama are indicated in Table VII. Results indicate that open-sunlight aging had the most severe effect on the laboratory-prepared materials, while the control materials improved somewhat in breaking strength. As shown in the table, three of the laboratory-prepared coated fabrics could

CHEMICAL RESISTANCE OF UNPIGMENTED AND BL

Chemical	Control Neoprene/ Nylon	Control Vinyl/ Nylon	L-100/ Nylon	L-100/ Cerex	2004/ Nylon	2004/ Cerex	
UNPIGMENTED COATINGS							
MIL-L-46000 Lubricating Oil	Very pronounced curling & twisting	No apparent effect	Sl. curling sl. staining	Sl. twisting, not tacky	Some yellow staining, not tacky	Some yellow staining, not tacky	
O-I-503 Insect Repellent	Slight curling, not tacky	Specimens curl, coating disintegrates	Sl. curling, not tacky	Great deal of curling, not tacky	Sl. curling, very tacky	Slight curling, very tacky	
TT-S-735, Type II Hydrocarbon Fuel	No apparent effect	No apparent effect	Great deal of curling, not tacky	Great deal of curling, not tacky	No apparent effect	No apparent effect	
BLACK PIGMENTED COATINGS							
MIL-L-46000 Lubricating Oil	See above	See above	No change	No change	No change	Slight curling	
O-I-503 Insect Repellent	See above	See above	Surface dulls, moderately tacky	Slightly wrinkled, slightly tacky	Slight curling, slightly tacky	Severe curling, not tacky	
TT-S-735, Type II Hydrocarbon Fuel	See above	See above	No change	No change	No change	Severe curling, not tacky	

TABLE VI
TANKS OF UNPIGMENTED AND BLACK PIGMENTED COATINGS

2004/ Nylon	2004/ Cerex	B602/ Nylon	B602/ Cerex	B605/ Nylon	B605/ Cerex	5714F1/ Nylon	5714F1/ Cerex
UNPIGMENTED COATINGS							
Some yellow staining, not tacky	Some yellow staining, not tacky	Some yellow staining, not tacky	Some yellow staining, pronounced curling and twisting	Some yellow staining, slight curling	Slight yellow stain, slight curling	No apparent effect	Slight yellow stain, slight curling
Sl. curling, very tacky	Slight curling, very tacky	No apparent effect	Slight curling, very slightly tacky	Slight curling, very slightly tacky	Slight curling, very slightly tacky	Slight curling, very tacky	Slight curling, very tacky
No apparent effect	No apparent effect	Slight curling, not tacky	Slight curling, not tacky	No apparent effect	No apparent effect	No apparent effect	Slight curling, not tacky
BLACK PIGMENTED COATINGS							
No change	Slight curling	Slight surface dulling	Slight curling, slight dulling	Slight dulling	Slight curling, slight dulling	Slight dulling	Slight dulling
Slight curling, slightly tacky	Severe curling, not tacky	Slight curling, slight dulling, slightly tacky	Slight curling, slightly tacky	Severe curling, some loss of coating, very tacky	Slight curling, extremely tacky	Complete loss of coating, extremely tacky	Complete loss of coating, extremely tacky
No change	Severe curling, not tacky	Slightly tacky	No change	No change	Slight curling, slight dulling	Slight dulling	Slight dulling

TABLE VII
COATED FABRICS AGED 6 MONTHS

Property	Neoprene/ Nylon Control			Vinyl/ Nylon Control			Adiprene L-100/ Nylon			Adiprene L-100/ Lantuck			Chemglaze Z001/ Nylon			Chemgl Z001/ Lantuck		
	O*	OS	RF	O	OS	RF	O	OS	RF	O	OS	RF	O	OS	RF	O	OS	RF
Breaking Strength, lbs., M.D. only	293	285	342	286	355	370	246	40	222	29	3.8	18.5	244	85	235	23	NT	NT
Thickness, inch	.021	.021	.021	.024	.025	.025	.019	.019	.020	.022	.020	.022	.018	.017	.018	.014	NT	NT
Presence of fungus (Visual)	-	No	No	-	No	Yes	-	No	Yes	-	No	Yes	-	No	Yes	-	Yes	Yes
Delamination (Visual)	NO DELAMINATION																	
Color change (Visual)**	-	2	5	-	2	5,7	-	3,4	3,4	-	3,4	6,7	-	3,4	3,4	-	3	3

- *O - Original property value
 OS - Open Sunshine aging in Panama
 RF - Rain Forest aging in Panama
 NT - No Test
 **1. - No change in coating
 2. - Coating color lightened
 3. - Coating brittle
 4. - Slight darkening of coating
 5. - Moderate darkening of coating
 6. - Severe darkening of coating
 7. - Coating mottled (probably due to fungus)

AGENT 6 MONTHS IN PANAMA

(TO BE USED ONLY AS A WORKSHEET . . . NOT TO BE OVERPRINTED . . . NOT TO BE OVERPRINTED)

not be tested due to extreme deterioration. All materials except the neoprene control showed evidence of fungus (debris, some viable) when returned from Panama.

In general, coated fabrics made from liquid urethane polymers are equal to or better than the currently available neoprene and vinyl materials, especially with respect to abrasion and ozone resistance, and low-temperature performance. However, liquid urethane polymers are not yet developed at the point in which they can be utilized without solvent dilution or special processing equipment. Thus, an economic disadvantage exists between the currently used neoprene and vinyl coated fabrics, and liquid urethane coated fabrics.

CONCLUSIONS

1. The viscosity of all liquid polymers with the exception of Chemglaze Z004 had to be reduced to approximately 50 per cent solids to facilitate any type of coating.
2. In almost all instances, the cross-direction breaking strength of the coated substrates was lower than that of the uncoated substrate. This may be due to entrapment of the load-bearing fibers that results in a type of brittleness in the fabric's cross direction.
3. All control and experimental urethane-coated fabrics (including one polyester material) were hydrolytically stable under the test conditions used.
4. Generally, the experimental coated-fabrics were superior to the commercial controls in abrasion resistance.
5. The commercial vinyl material and the Estane polyurethane coated-fabric were subject to severe deterioration by O-I-503 insect repellent.
6. Six months' open-sunlight aging had a more deteriorating effect on laboratory-prepared coated fabrics than the rain-forest aging.
7. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered

little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

RECOMMENDATIONS

1. Studies on new liquid polymers, tie-coatings, and substrates should be continued to achieve improvements in future development of fabric coatings in weapon accessories.
2. A hydrolytic stability test should be developed specifically for coated fabrics.

LITERATURE CITED

1. Kirk-Othmer, Encyclopedia of Chemical Technology,
Volume 5, John Wiley (New York), 1968.
2. Encyclopedia of Polymer Science and Technology,
Volume 6, Interscience (New York), 1968.
3. Garland, W. F., "Liquid Polymers as Coatings for
Improved Coated Fabrics," U. S. Army Weapons
Command, Weapons Laboratory at Rock Island,
Technical Report RE-TR-71-51, July 1971.
4. Military Specification, MIL-C-20696, Cloth, Coated,
Nylon, Waterproof.
5. Saunders, A. C., "Nonwoven Materials as Improved
Substrates for Coated Fabrics," U. S. Army Weapons
Command, Science and Technology Laboratory,
Technical Report RE-TR-70-162, November 1970.
6. Testroet, F. B., "Hydrolytic Stability of Commercial
Polyurethane Vulcanizates," U. S. Army Weapons
Command, Science and Technology Laboratory,
Technical Report 68-3276, November 1968.
7. Testroet, F. B., "Performance of Urethane Vulcan-
izates in Environments of High Humidity," Rock
Island Arsenal Laboratory, Technical Report
63-2808, August 1963.

DISTRIBUTION

Copies

A. Department of Defense

Office of the Director of Defense
Research & Engineering
ATTN: Mr. J. C. Barrett
Room 3D-1085, The Pentagon
Washington, D. C. 20301

1

Defense Documentation Center
ATTN: TIPDR
Cameron Station
Alexandria, Virginia 22314

12

B. Department of the Army

Commanding General
U. S. Army Materiel Command
ATTN: AMCRD-GF
AMCRD-TC
AMCRD-R, Mr. H. Cohen
Washington, D. C. 20315

1

1

1

Commanding General
U. S. Army Tank-Automotive Command
ATTN: AMSTA-RPL Technical Library
AMSTA-RK Materials Laboratory
Warren, Michigan 48090

1

1

Commanding General
U. S. Army Weapons Command
ATTN: AMSWE-RD
AMSWE-PP
Rock Island, Illinois 61201

1

1

Commanding General
U. S. Army Missile Command
ATTN: Documentation & Technical Info. Br.
AMSMI-RRS
AMSMI-RSM
Redstone Arsenal, Alabama 35809

2

1

1

DISTRIBUTION

Copies

Commanding General U. S. Army Munitions Command Picatinny Arsenal Dover, New Jersey 07801	1
Commanding General Quartermaster R&D Command Natick, Massachusetts 01760	1
Commanding General U. S. Army Electronics Command ATTN: AMSEL-KL-EE Fort Monmouth, New Jersey 07703	1
Commanding Officer Army Materials and Mechanics Research Center Watertown, Massachusetts 02172	1
Commanding Officer Frankford Arsenal ATTN: SMUFA-L1000 Library, C2500 Philadelphia, Pennsylvania 19137	1 1
Commanding Officer Watervliet Arsenal ATTN: SWEV-RDR SWEV-RDT Library Watervliet, New York 12189	1 1
Commanding Officer Picatinny Arsenal ATTN: Plastics & Packaging Lab. PLASTEC Dover, New Jersey 07801	1 1
Commanding Officer U. S. Army Production Equipment Agency ATTN: AMXPE Rock Island Arsenal Rock Island, Illinois 61201	1

DISTRIBUTION

Copies

Commanding Officer U. S. Army Research Office (Durham) Box CM, Duke Station Durham, North Carolina 27706	1
U. S. Army Research & Development Group (Europe) ATTN: Chief, Chemistry Branch APO New York 09757	1
Commanding Officer U. S. Army Chemical & Coating Laboratory ATTN: Dr. C. Pickett Technical Library Aberdeen Proving Ground, Maryland 21005	1 1
Commanding Officer U. S. Army Environmental Health Laboratory Army Chemical Center, Maryland 21010	1
Commanding Officer U. S. Army Engineer R&D Laboratories ATTN: Technical Library Army Chemical Center, Maryland 21010	1
Commanding Officer U. S. Army Engineer R&D Laboratories ATTN: Chemistry Research Section, Materials Branch Fort Belvoir, Virginia 22060	1
Commanding Officer U. S. Army Medical Biomechanical Research Laboratory - ATTN: Library Fort Detrick, Bldg. 568 Frederick, Maryland 21701	1
Commanding Officer U. S. Army Tropic Test Center ATTN: STETC-MO-A Technical Library Brewer 942 Fort Clayton, Canal Zone 09827	1

DISTRIBUTION

Copies

U. S. Army Reactor Branch
Division of Reactor Development
Atomic Energy Commission
Washington, D. C. 20545 1

Commanding Officer
Tobyhanna Army Depot
ATTN: SMC Packaging and Storage Center
Tobyhanna, Pennsylvania 18466 1

Director
Joint Military Packaging Training Center
ATTN: AMXPT-PT
Aberdeen Proving Ground, Maryland 21005 1

Commanding Officer
U. S. Army Aviation School
ATTN: Office of the Librarian
Fort Rucker, Alabama 36362 1

C. Department of the Navy

Commander
Naval Ordnance Systems Command
Department of the Navy
ATTN: RMMP
Room 2225, Munitions Building
Washington, D. C. 20360 1

Commander
Department of the Navy
Office of Naval Research
ATTN: Code 423
Washington, D. C. 20360 1

Commander
Department of the Navy
Naval Ships Systems Command
ATTN: Code 344
Washington, D. C. 20360 1

DISTRIBUTION

Copies

Commander Department of the Navy Special Projects Office ATTN: SP 271 Washington, D. C. 20360	1
Commander U. S. Naval Ordnance Laboratory ATTN: Code WM White Oak Silver Spring, Maryland 20910	1
Commander Naval Supply Systems Command SUP 0442 Department of the Navy Washington, D. C. 20360	1
Director Aeronautical Materials Laboratory Naval Air Engineering Center Philadelphia, Pennsylvania 19112	1
Commander Naval Ordnance Systems Command Department of the Navy ATTN: RRMA-54 Washington, D. C. 20360	1
Commander (Code 753) U. S. Naval Ordnance Test Station ATTN: Technical Library China Lake, California 93557	1
Commander U. S. Naval Research Laboratory ATTN: Technical Information Center Anacostia Station Washington, D. C. 20390	1

DISTRIBUTION

Copies

Commander
San Francisco Bay Naval Shipyard
Mare Island Division
ATTN: Rubber Laboratory
Vallejo, California 94592

1

D. Department of the Air Force

Headquarters, U. S. Air Force
AFDASFB
Room 4D-313, The Pentagon
Washington, D. C. 20330

1

Commander
Wright Air Development Division
ATTN: AFM
Materials Central
Wright-Patterson Air Force Base, Ohio 45433

1

1

ARDC Flight Test Center
ATTN: Solid Systems Division, FTRSC
Edwards Air Force Base, California 93523

1

AFML (MATF)
Manufacturing Technology Division
Wright-Patterson AFB, Ohio 45433

2

E. Other Government Agencies

George C. Marshall Space Flight Center
National Aeronautics & Space Administration
ATTN: M-S&M-M
M-F&AE-M
Huntsville, Alabama 35812

1

1

This page intentionally left blank.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D		
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY (Corporate author)		2a. REPORT SECURITY CLASSIFICATION
U. S. Army Weapons Command Research, Dev. and Eng. Directorate Rock Island, Illinois 61201		Unclassified
		2b. GROUP
3. REPORT TITLE		
LIQUID POLYMERS AS COATINGS FOR IMPROVED COATED FABRICS (U) (Supplement to RE-TR-71-51)		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)		
5. AUTHOR(S) (First name, middle initial, last name)		
William F. Garland		
6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1972	24	7
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)	
8. PROJECT NO. DA 1T062105A329	SWERR-TR-72-65	
c. AMS Code 502E.11.295	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
10. DISTRIBUTION STATEMENT		
Distribution limited to U. S. Government agencies only; (Test and Evaluation); September 1972. Other requests for this document must be referred to U. S. Army Weapons Command, SWERR-R.		
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY
		U. S. Army Weapons Command
13. ABSTRACT		
<p>Results are presented for the second years' effort of a two-year program initiated by personnel of the Research Directorate, Weapons Laboratory, WECOM concerning the use of liquid polymers as coatings for fibrous and nonfibrous substrates to provide improved weapon accessories such as gun covers and cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength. (U) (Garland, William F.)</p>		

DD FORM 1473

NOV 66 1473 1 JAN 66, WHICH IS EYE FOR ARMY USE.

Security Classification

~~Unclassified~~
~~Security Classification~~

14		KEY WORDS		LINK A		LINK B		LINK C	
				ROLE	WT	ROLE	WT	ROLE	WT
1. Liquid Polymers									
2. Urethane									
3. Nonwoven Materials									
4. Polyethylene									
5. Plastic Coatings									

~~Unclassified~~
~~Security Classification~~

AD U. S. Army Weapons Command Research, Dev. and Eng. Directorate Rock Island, Illinois 61201	Accession No.	UNCLASSIFIED
LIQUID POLYMERS AS COATINGS FOR IMPROVED COATED FABRICS (Supplement to RE-TR-71-51), by William F. Garland		1. Liquid Polymers
Report SWERR-TR-72-65, Sep 72, 24 p. Incl. illus. tables, (DA Project 1T062105A329, AMS Code 502E.11.295) Unclassified report.		2. Urethane
Results are presented for the second years' effort of a two-year program initiated by personnel of the Research Directorate, Weapons Laboratory, WECOM, concerning the use of liquid polymers as coatings for fibrous and nonfibrous substrates to provide improved weapon accessories such as gun covers and		3. Nonwoven Materials
(Cont.) over	(Cont.) over	4. Polyethylene
DISTRIBUTION		5. Plastic Coatings
Copies obtainable from DDC		DISTRIBUTION Copies obtainable from DDC

AD U. S. Army Weapons Command Research, Dev. and Eng. Directorate Rock Island, Illinois 61201	Accession No.	UNCLASSIFIED
LIQUID POLYMERS AS COATINGS FOR IMPROVED COATED FABRICS (Supplement to RE-TR-71-51), by William F. Garland		1. Liquid Polymers
Report SWERR-TR-72-65, Sep 72, 24 p. Incl. illus. tables, (DA Project 1T062105A329, AMS Code 502E.11.295) Unclassified report.		2. Urethane
Results are presented for the second years' effort of a two-year program initiated by personnel of the Research Directorate, Weapons Laboratory, WECOM, concerning the use of liquid polymers as coatings for fibrous and nonfibrous substrates to provide improved weapon accessories such as gun covers and		3. Nonwoven Materials
(Cont.) over	(Cont.) over	4. Polyethylene
DISTRIBUTION		5. Plastic Coatings
Copies obtainable from DDC		DISTRIBUTION Copies obtainable from DDC

cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

AD U. S. Army Weapons Command Accession No. _____
Research, Dev. and Eng. Directorate
Rock Island, Illinois 61201

LIQUID POLYMERS AS COATINGS FOR IMPROVED
 COATED FABRICS (Supplement to RE-TR-71-51),
 by William F. Garland

Report SWERR-TR-72-65, Sep 72, 24 p. incl.
 illus. tables, (DA Project IT06210SA329, AMS
 Code 502E.11.295) Unclassified report.

Results are presented for the second years' effort of a two-year program initiated by personnel of the Research Directorate, Weapons Laboratory, WECOM, concerning the use of liquid polymers as coatings for fibrous and nonfibrous substrates to provide improved weapon accessories such as gun covers and

(Cont.) over

UNCLASSIFIED

1. Liquid Polymers
2. Urethane
3. Nonwoven Materials
4. Polyethylene
5. Plastic Coatings

DISTRIBUTION
 Copies obtainable
 from DDC

UNCLASSIFIED

1. Liquid Polymers
2. Urethane
3. Nonwoven Materials
4. Polyethylene
5. Plastic Coatings

DISTRIBUTION
 Copies obtainable
 from DDC

AD U. S. Army Weapons Command Accession No. _____
Research, Dev. and Eng. Directorate
Rock Island, Illinois 61201

LIQUID POLYMERS AS COATINGS FOR IMPROVED
 COATED FABRICS (Supplement to RE-TR-71-51),
 by William F. Garland

Report SWERR-TR-72-65, Sep 72, 24 p. incl.
 illus. tables, (DA Project IT06210SA329, AMS
 Code 502E.11.295) Unclassified report.

Results are presented for the second years' effort of a two-year program initiated by personnel of the Research Directorate, Weapons Laboratory, WECOM, concerning the use of liquid polymers as coatings for fibrous and nonfibrous substrates to provide improved weapon accessories such as gun covers and

(Cont.) over

UNCLASSIFIED

1. Liquid Polymers
2. Urethane
3. Nonwoven Materials
4. Polyethylene
5. Plastic Coatings

DISTRIBUTION
 Copies obtainable
 from DDC

UNCLASSIFIED

1. Liquid Polymers
2. Urethane
3. Nonwoven Materials
4. Polyethylene
5. Plastic Coatings

DISTRIBUTION
 Copies obtainable
 from DDC

cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.

cleaning kit packets. Both pigmented and nonpigmented coatings were investigated. Application of solvent-diluted polymer coatings to woven substrates caused a significant loss in cross-direction breaking strength. Base or tie coats (consisting of liquid diamines applied to the substrate prior to application of liquid polymers) did not significantly improve the tear strength of the coated fabrics made from either woven or nonwoven substrates. Except for the Estane solution coating, the polyurethane liquid polymers were generally resistant to a hydrocarbon fuel, lubricating oil, and insect repellent. Six months' open sunlight aging in Panama was generally more severe than rain forest aging on both the pigmented and nonpigmented coated fabrics. The best combination of breaking and tear strength and resistance to accelerated aging was obtained with either a pigmented or nonpigmented liquid polyurethane coated on a Betaglass/Dynel substrate. These experimental materials had abrasion resistance equal to or better than that of the vinyl control and two to three times better than that of the neoprene control. The black pigmented material suffered little or no loss in tear strength after accelerated aging while the control materials lost 10 to 20 per cent in tear strength.